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for.

Youngsoo Son

Project Manager

Email: youngsoo.son@doosan.com
Doosan Heavy Industries & Construction Co., Ltd.

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UPPER TRISHULI-1 HEP (216MW)			
Client	**Nepal Water and Energy Development Company Private Limited**		
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Contractor	**Doosan Enerbility**		
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Comments

On 06 June 2022 the Contractor has submitted for review to the OE the document PHYSICAL HYDRAULIC MODEL TEST STUDY REPORT OF WEIR (UT1-C-020-CVL-TE-40012). The Owner's Engineer has reviewed the document and comments are given below.

General

- The study report should be clearly structured and include (at least) the following:
  - Model description and measurement techniques
  - Test program
  - Model laws
  - Calibration of model
  - Base design as a start
  - Modifications as required
  - Final recommended layout
- Drawings are the language of the engineer. If the report is written in a foreign language, then it is even more important to support the text by sufficient good quality drawings and photographs in order to assure a successful communication between parties.
- Drawings should include all relevant key dimensions.
- Drawings which show scouring elevations and natural elevations should both carry legible contour information. They should be supported with photographs documenting scouring in the dry (after carefully and slowly having drained the water from the model).
- It has not been made clear which main discharges were selected for deciding on major modifications! Which indicators have been used to decide: water levels? Velocity and flow mapping? Turbulence? Bed levels and scour depth?
- Documentation of results and measurements from various test series should be included as an Annex to the report.

Below are comments related to the individual chapters of the model test study report:

1. Introduction

- This chapter includes a brief general project description. Missing is the purpose of the hydraulic model test study. Also, a reference to earlier model tests for the project should be included and why these new tests have been deemed necessary (the paragraph included under chapter 4.1 does not satisfy this requirement).

2. Main Structures of Weir/Dam

- Which design was studied in the hydraulic model tests? It is not clear which design is described in this chapter 2. It should be the design with which the model test started. Is this the originally contractual design? Or is this already a modified design? If so, then there should be a brief history of the development given. Weir and sluice gates are not the original (contractual) but newly designed. The intake is newly designed, too.
- The design includes now a fish passage, separately for moving upstream and downstream along the left bank (Figure 2.1-1). However, it is not clear whether the structural elements have been included in the model tests.
- The cofferdam description is not clear (to include drawing(s)!). What is 'the lower main weir' and 'the upper sub-weir'? (again: to include drawings for clarity!)

3. Hydrological and Sediment Data

- Chapter 3.1: No such requirement of fulfilling a design flood standard (3) of a 200-year return flood for *'downstream energy dissipation and erosion control of the dam'* is included in Annex 13 Employer's Requirement, B1- 2.3 Design Flood.
- Table 3.4-1: For which conditions are the water levels given? Is this for the current natural prototype situation? Or is that for a later stage during construction?
- Table 3.6-1: Downstream water level: where? At which location along the longitudinal section?

4. Test Purposes and Contents

- Chapter 4.1 does not state that the start of the tests should be the contractual design, which through the model tests should be improved (*'verified and optimized'*) as necessary.
- The testing scope should include the hydraulic performance of weir with axis and gates, but also the intake structure (not only the sedimentation at the intake).
- Chapter 4.2: It is not clear what the term "desander basin" refers to. The term should be used for the desander basins located further downstream along the power conduit (the three desander caverns).
- A total of 11 different test tasks are listed to be included in the scope for the performance of the model tests. However, these are individual aspects; there is no structure or concept of the model tests visible or described.

5. Model Design and Fabrication

- Chapter 5.1.2: Here the criteria selected for achieving a similarity in the model should be reported. Besides the dynamic similarity (Froude model law), the similarity of sediment material should be discussed. For bedload motion, shear stress plays a major role. Therefore, the similarity regarding Fr_* (Froude number of the grain) and the incipient velocity should be discussed.
- No particle size distribution for the sediment studied is included or referred to. Is it true that there are no bed load particles of size <27 mm? What is the meaning of giving a range of diameter for d_{50}? Include the particle size distribution curve.
- Chapter 5.2: When referring to the Terms of Reference, these should be included (in an Annex; without the reference has no value).
- Figure 5.2-1: The plan layout shown on this map seems not to be identical with the plan layout in the original DKJV design. However, no details can be taken from this overview map nor any other layout drawing.
- No explanation (sub-chapter) regarding model calibration is given.

6. Test Results of Cofferdam Overflow

- Chapter 6.1 and 6.2: Velocity profiles, at least at the weir axis, upstream and downstream of it, should be taken to compare the situation prior and after modifications.
- Picture 6.2-1: The photo shows a non-acceptable flow pattern due to its uneven distribution across the section and deflection at the foot of the dam. What were the consequences out of this unacceptable flow pattern? (The weir location should have been indicated by a different colour; the reflections on the water surface should be avoided to achieve an acceptable quality and added value of such photos.)
- Picture 6.2-4: Where is the cofferdam? Except for standing waves, it is difficult to relate the photo to the design and take information from it.
- The cofferdam heights indicated in Figures 6.6-6 and 6.6-7 are different, i.e. 1,253 masl vs. 1,250 masl!
- Tests should be carried out for the correct cofferdam height (which in turn also may affect the flow distribution between tunnel and cofferdam).
- Important is to compare tests for same discharge and identify areas with increased/changed velocities in tests without and with cofferdam. These areas are endangered to increased erosion.

7. Test Results of Physical Hydraulic Model of the Weir/Dam

- Chapter 7 alone covers more than half of the report.
- Chapter 7.1: What is the "Preliminary Scheme"?
- Chapter 7.1.1: What is the "preliminary design scheme"?
- No data or explanation regarding model calibration is given.
- What is the scope of testing? Which test series have been conducted? Which results have been recorded? (Water level? Flow velocities? Flow pattern? Discharge?). In order to prove (hydraulic) improvements, documentation of the base case is required.
- Figure 7.2.1: It is not clear what is the difference between the bold black line and the green line. Text and numbers are not legible.
- Chapter 7.2.1: What are the findings and conclusions from the test series (which discharges were tested?) carried out for left bank approach flow improvement studies?
- Chapter 7.2.2: What is the conclusion from the test with a 4 m high weir step included (any drawing or sketch for explanation)?
- Chapter 7.2.3: The test results should be supported with velocity measurements and sketches of flow patterns, in particular describing the effect on the approach flow upstream of the weir and to the flow pattern downstream of the weir. Which discharges have been tested? Which ones were relevant for the recommendation of the final rotation of the weir axis?
- Chapter 7.2.4: Changing dimensions of flood openings is a major change. This should be supported through documentation. No photos, no velocity profiles, no water level profiles are included for this in the report.
- Did the reduction of the width of the openings resulted in larger piers? Or a new centre line? Or moving all openings to the right or to the left in the layout? The modification should be shown in a proper drawing.
- Chapter 7.2.5: The flow pattern partially visible in Pictures 7.2-4 and 7.2-5 (included in chapter 7.2.3) cannot be regarded as the only proof of having achieved acceptable flow conditions for the final layout configuration (if this is actually the one recommended for implementation?).
- Figure 7.2-3: The layout shows downstream of the apron a huge area lowered to elevation 1,235 masl on the left bank. What is the status of this area? What are the critical flow velocities at the downstream end? How does the flow pattern look like? Against which velocities the riprap has to be designed to be stable and not to erode the river bed nor the river bank? Is there any excavation foreseen in the upstream part? What is the impact on the fish passage which was shown in an earlier drawing along the left bank and entire length of the apron? What are the individual discharge figures for each of the three gate openings (left, centre, right)? Has an even flow distribution been achieved? What happened to the 4 m step which was introduced into the design in chapter 7.2.2 above?

- Missing Chapter 7.3: Chapter 7.1 – '*Test results of preliminary scheme*', chapter 7.2 – '*Flow pattern optimisation test in reservoir area*'. The next chapter - which is however missing – should be '*Test results for optimised and recommended scheme layout*'!
- Chapter 7.3: Third paragraph: the text from "Figure 7.3-1 shows ..." and following four paragraphs and its meaning is not clear.
- What was the downstream water level on the apron for fully open gates? Any impact from tailwater level? Is there a downstream rating or tailwater curve?
- Are the discharge released through the three gates even? The photos and comments on observation during the model tests give a strong impression that discharge at the three gates are very uneven. Flow velocities should be measured during the tests to determine discharge distribution through the three openings.
- Chapter 7.4: In this chapter it is confirmed that flow velocities, and thus the discharges through the three openings are not equal. This invalidates the "calibrated" discharge capacities reported in Chapter 7.3 above.
- There is no optimisation reported trying to improve flow conditions for and distribution of the three openings. Therefore the understanding is that this is a preliminary result of the investigations. Are there final investigations to follow?
- Chapter 7.5: With non-acceptable, non-balanced, non-equal flow distribution through the three openings, the test results for pressure distribution only for the centre opening cannot be accepted as representative.
- Chapter 7.6: This chapter extends over 28 pages. By its sheer size this must be representing the most important part of the model tests!
- The design standard listed as the 200-year return flood deviates from the design floods chosen for the weir, which is 10,000-year for the weir, 2,000-year return flood for the case 1 gate malfunctioning, and 5,000-year according to the DOED design standard.
- What are "scour materials" and "scour velocity of 8 m/s"?
- Formula 7.6-1: symbols used in formula and defined below do not match: D and d, n and v. There are other formulas to define the begin of movement for riprap, which includes the turbulence in the dimensioning of riprap. The scour velocity (velocity at which movement of riprap particles starts) has been calculated as 7.35 m/s.
- How and which riprap has been designed at the end of the apron?
- How has the tailwater level been chosen, calibrated and selected in the model tests?
- Chapter 7.6.1: Picture 7.6-1: The flow at the left bank and the end of the "excavation area" is subject to high velocities. Reported velocities are 16 m/s, and between 7 m/s and 11.6 m/s at the right bank. This leads immediately to erosion and removal of riprap protection at the end of the apron! Consequences are not mentioned!
- Chapter 7.6.2: Figure 7.6-8: What is the difference when compared to Figure 7.6-1. The design change between the two layouts should be indicated.
- What are slope inclinations? What are slope protection measures for the excavated slope section? Or against which load cases the slope has to be protected as derived from the model tests?
- Pictures 7.6-1 and 7.6-2 are taken from different viewpoints. A real comparison of flow conditions is therefore not provided by these photos. No significant difference is visible.
- Chapter 7.6.3: Four (4) modifications have been studied. It is not clear which of these modifications have improved the hydraulic performance? Which of the measures are recommended for implementation? The proposal of a flip bucket at the downstream end of the apron is not clear. It requires a layout drawing and a longitudinal section to be shown.
- Photographs documenting the scouring depth and patterns are missing.
- Proper layout drawings and sections should be presented.
- Photographs of the modifications (in dry condition) would help to visualise the modifications.

8. Conclusions and Suggestions

- 11 points, which reflect the main scope of the model tests, are listed: (i) existing flow velocities, (ii) uneven and irregular overflow condition at cofferdam, (iii) inflow condition at preliminary design

scheme, (iv) adjustment of weir axis, (v) size of openings, (vi) flow through openings, (vii) flow velocity at sluices, (viii) pressure condition at bottom slab, (ix) apron for energy dissipation, (x) flip bucket at end of apron, and (xi) large size of riprap at end of apron.

- However, for almost none of the above eleven points studied, executed studies have been described satisfactorily and/or layout changes resulting from an optimisation been adequately documented (according to the description provided in this reviewed report) to approve the proposed design change for the weir.
- In particular, no recommendations have been presented regarding improvement of cofferdam hydraulics.
- Hydraulics of the „preliminary layout" have been described as insufficient. A 15° anti-clockwise rotation of the weir axis has been recommended. However, approach flow and discharge through the three gates remains hydraulically unsatisfactory.
- A summary of the final hydraulic project layout configuration must be included, giving in sufficient detail the information needed to implement the design.

Remarks

Physical hydraulic model tests had already been carried out in 2013/2014 in Kathmandu at the Hydro Lab Laboratory in Lalitpur. The tests were carried out for a base design and focussed on the power intake arrangement and guide walls improving the hydraulics of the original DKJV design which included a weir with radial gates and stilling basin.

It is not clear what is the difference in layout arrangements between the original DKJV (contractual) design and the design resulting from the 2022 model tests? This in particular with regards to weir axis, weir orientation, location of gates and location of power intake tower. The design as a result of the 2013/2014 model tests has many aspects already optimised.

There is no statement which clarifies the improvements and/or advantages of the 2022 design of the Contractor when compared to the DKJV (contractual) design?

DISCLAIMER

Any approval will not release the Contractor from any of his obligations under the Contract.

for Dr Frank Negrassus

(Signature)